5-2004

Aniline Sensor Based on Nanodimensional Reaction with Carbon Nanotubes: Helpful for Fighting Bioterrorism

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ANILINE SENSOR BASED ON NANODIMENSIONAL REACTION WITH CARBON NANOTUBES: HELPFUL FOR FIGHTING BIOTERRORISM

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Why is a chemical sensor necessary?

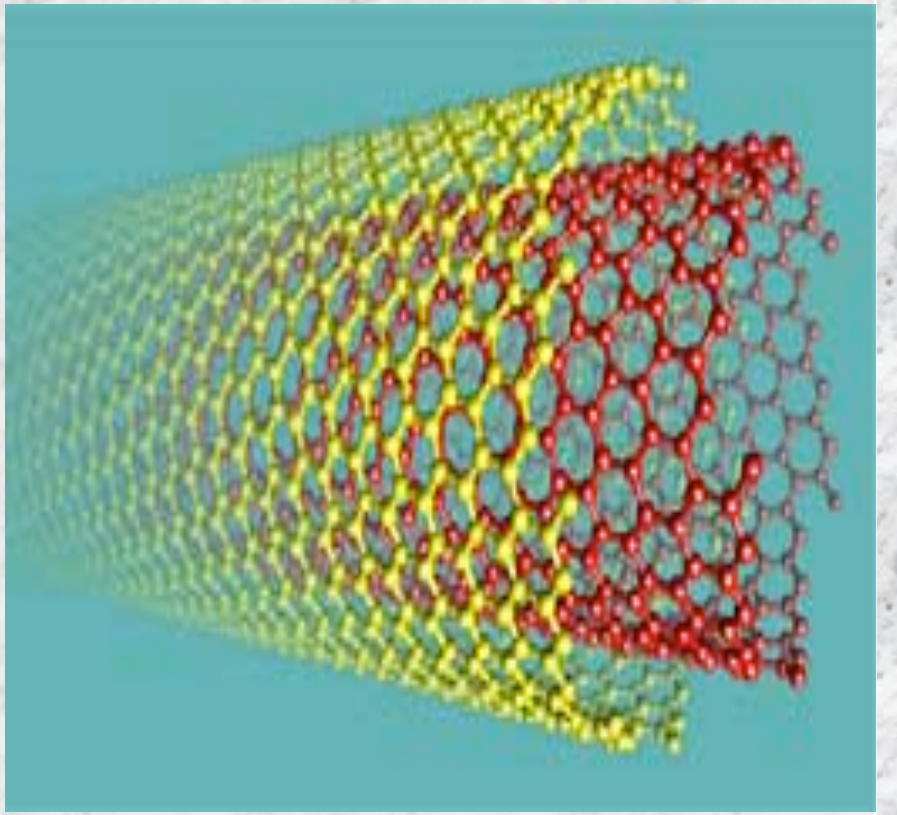
- The possibility of a bioterrorist attack using a poisonous organic chemical requires that precautions be taken
- Aniline and other aromatic amines are possible choices for this type of attack
- Early detection of these chemicals would allow for evacuation of people in an affected area
- The dye production industry also makes use of aniline and similar compounds, so inexpensive safety precautions would be helpful

Aniline Poisoning

- Aniline poisoning results in asphyxiation due to attack on hemoglobin in red blood cells
- The EPA suggested toxic limit for aniline: not to exceed 50-500mg/kg
- The MSDS for aniline lists Oral – Rat LD50 as 250mg/kg
- Typical workplace detection methods for aniline involve Gas Chromatography

Functionalized Carbon Nanotubes

- Produced via graphite placed in a 20V, 90A arc
- Functionalized by the addition of a Carboxylic Acid group
- Typical diameter of a MultiWalled FCNT is ~10nm, however there is some variance.



Previous Work

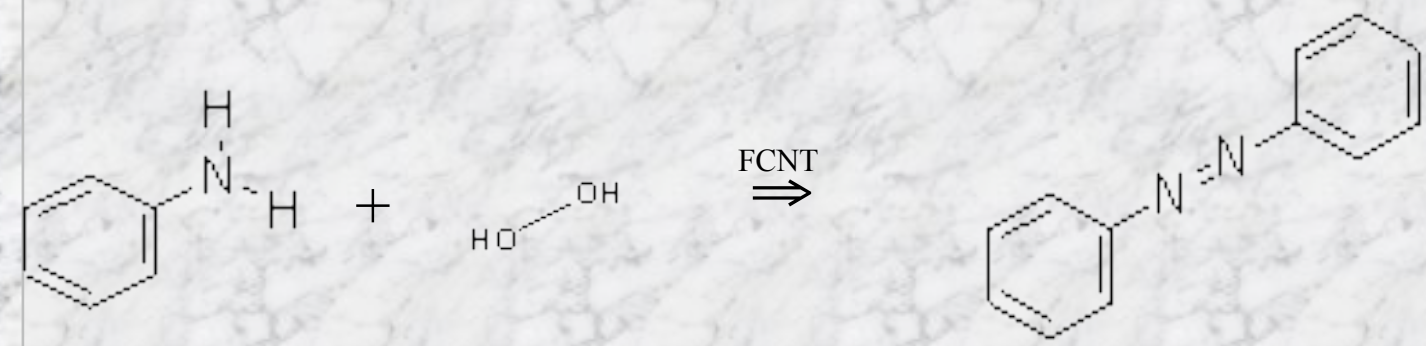
- It has been shown that functionalized carbon nanotubes (FCNT) catalyze the conversion of aniline to azobenzene, and p-toluidine to azotoluene[1].
- Study of this reaction had been successful to concentrations approaching 5mM

1. *Croston, Et al. Intl Jrnl of Nano. 2002.*

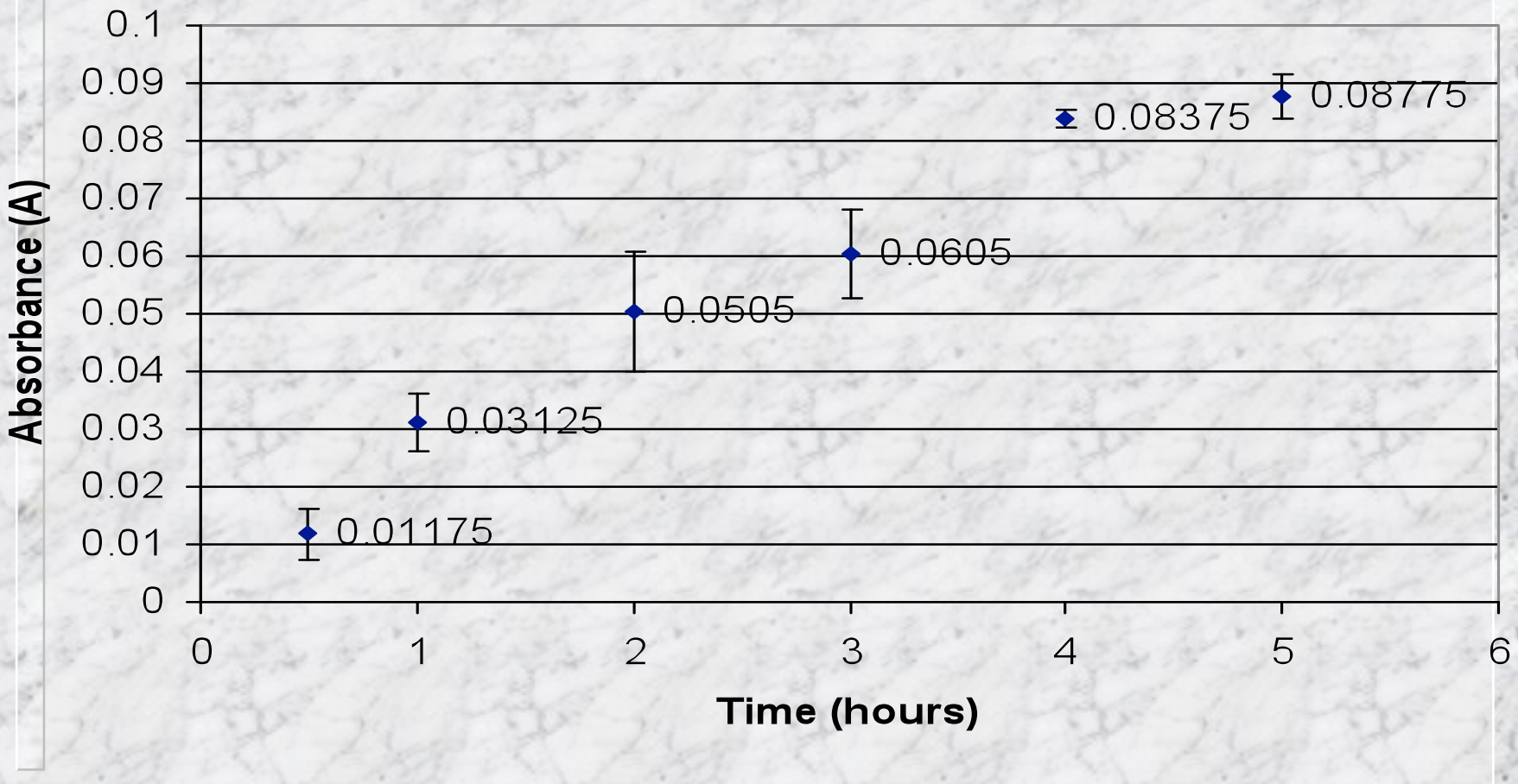
Theorized Reaction Pathway inside of a FCNT

NANODIMENSIONAL REACTION
Aniline to Azobenzene Conversion Data

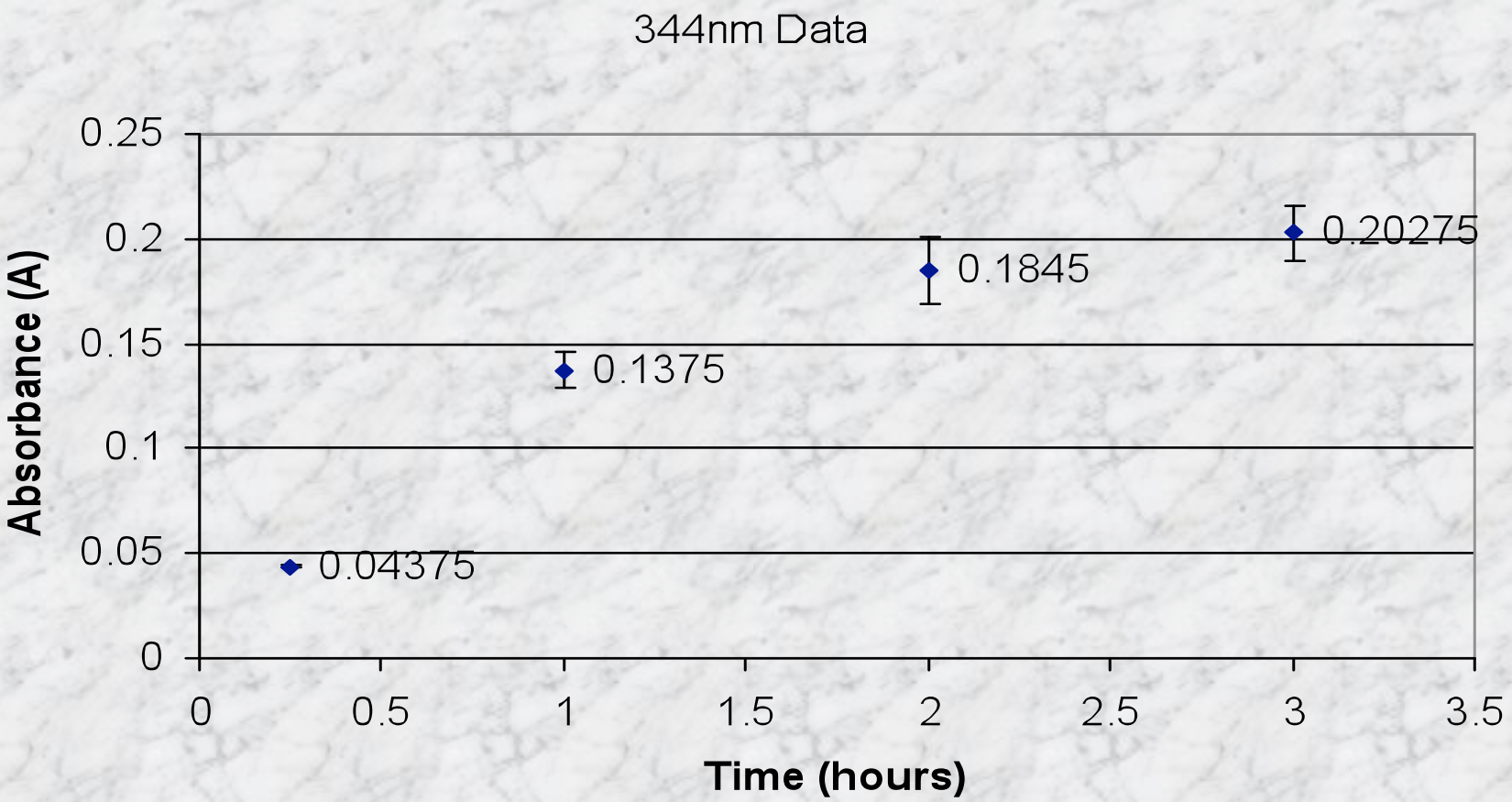
- Absorbance found at 344nm
- Solutions were held at room temperature
- Four replicates were used to find a standard deviation



5mM Aniline + 5mM H2O2 Data



Centrifuged 5mM Aniline+5mM H2O2

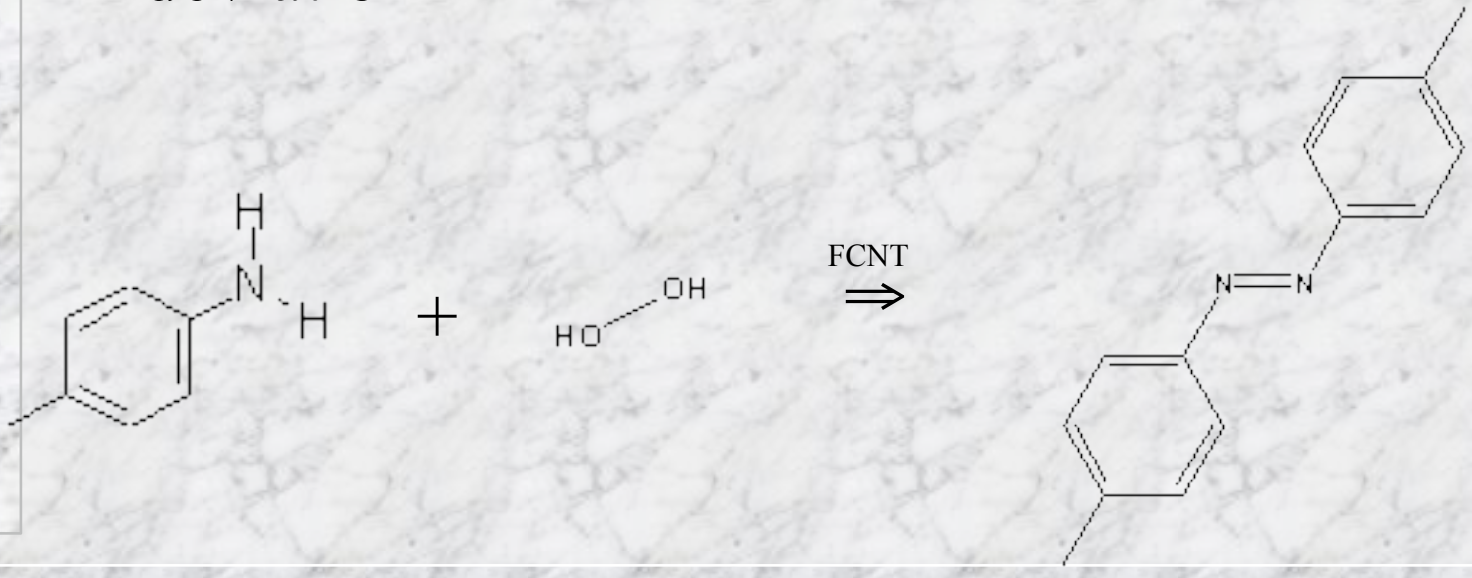


NANODIMENSIONAL REACTION

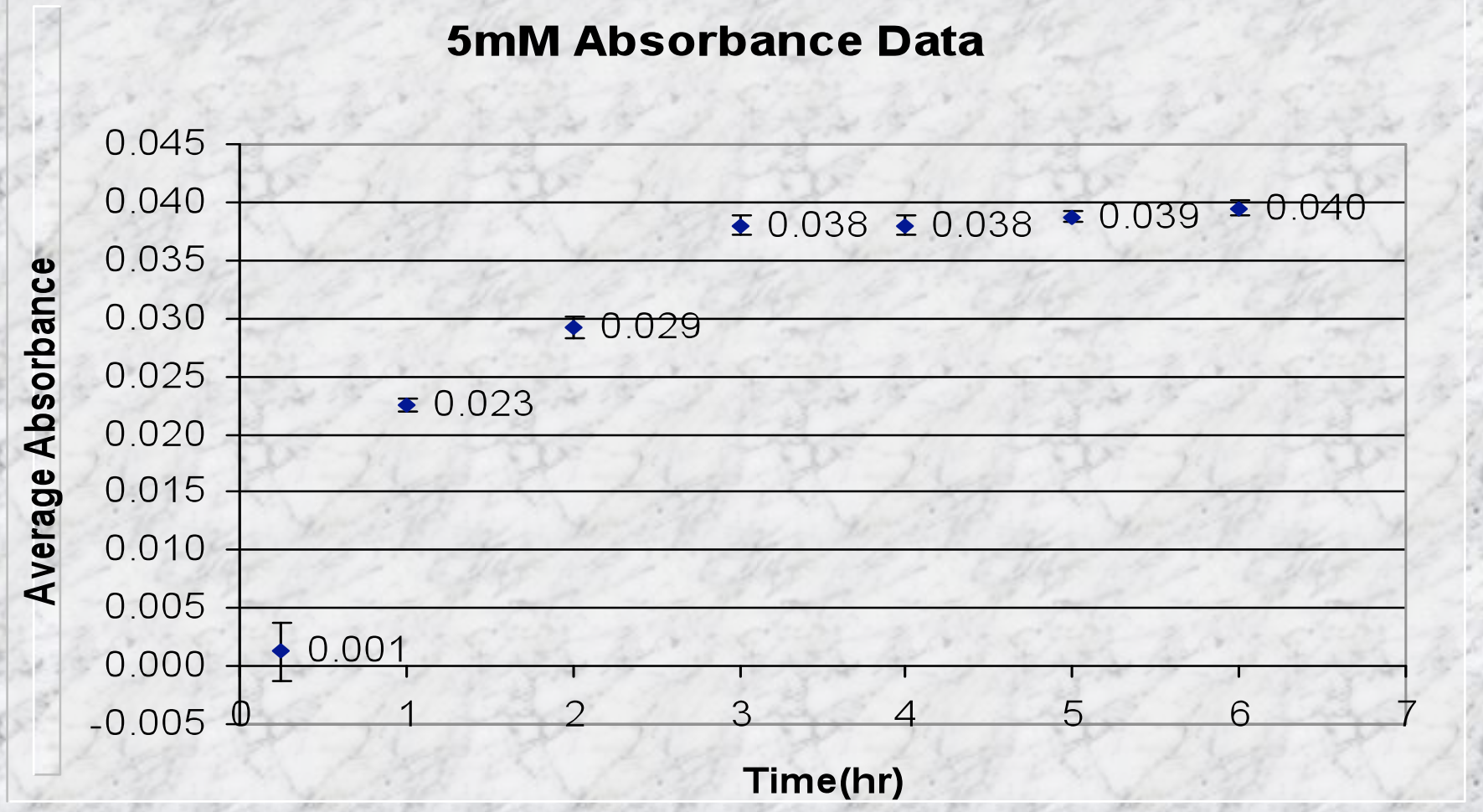
para-Toluidine to Azotoluene

Conversion Data

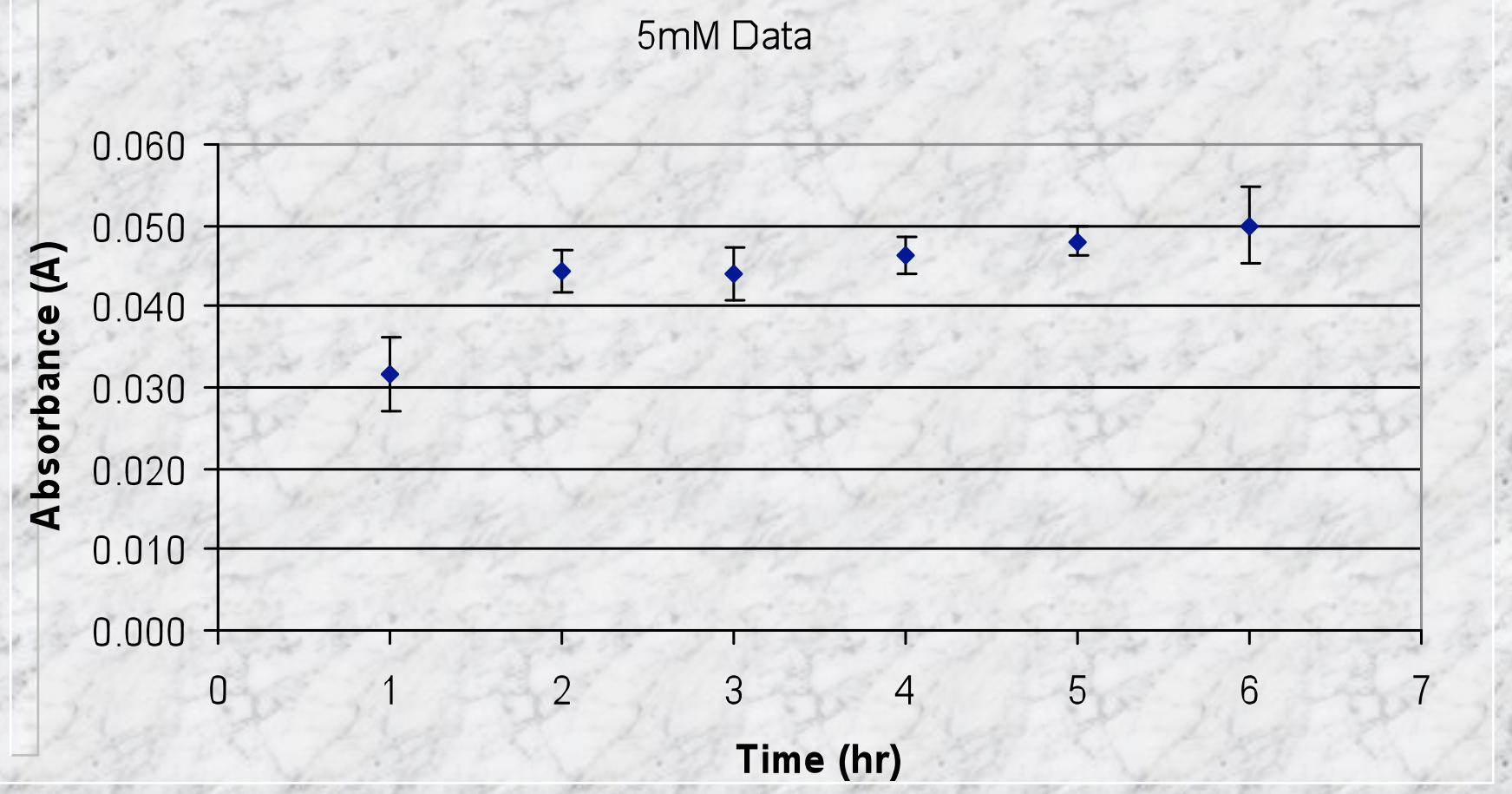
- Absorbance found at 460nm
- Solutions were held at room temperature
- Four replicates were used to find a standard deviation



5mM p-Toluidine+5mM H2O2



Centrifuge
5mM p-Toluidine+5mM H2O2



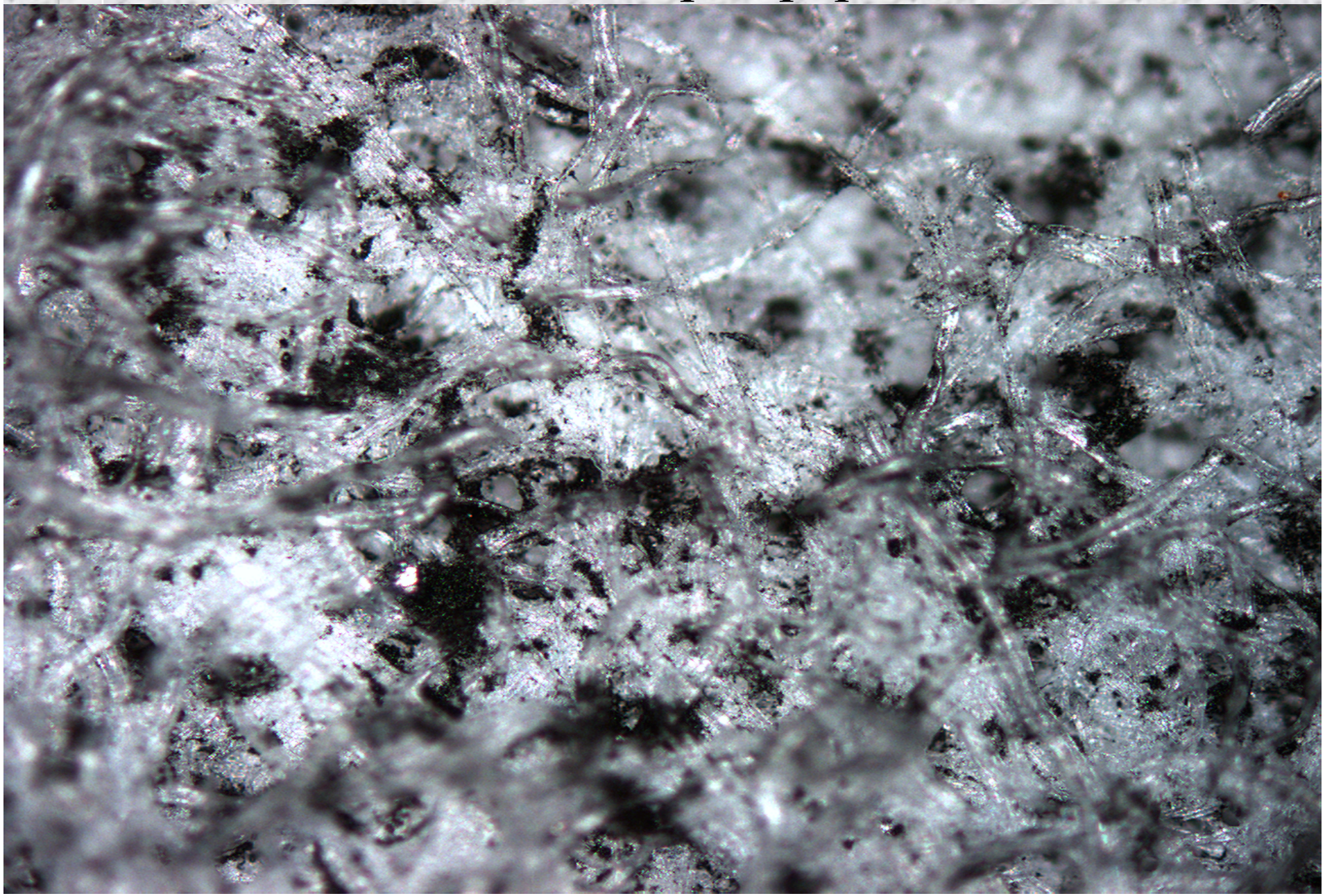
Chemical Sensor Application: Paper test strips

- FCNTs could be used to determine aniline vapor in low concentrations, specifically, on the order of 5mM in air
- FCNTs were doped onto paper strips
- The pores of the paper were filled with aggregations of the FCNTs

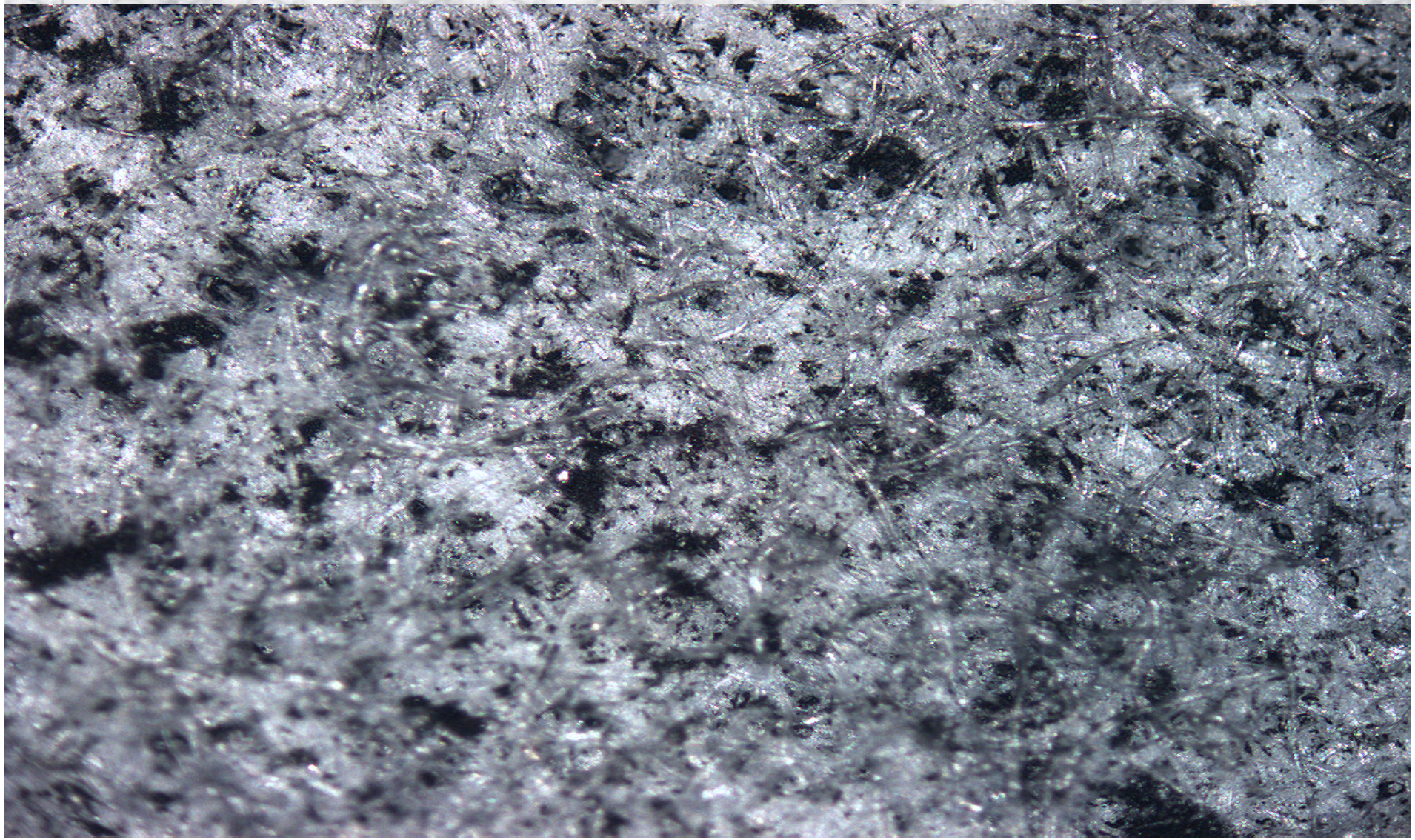
Paper Sensor Preparation

- The FCNT doped strips were adhered to slides
- The strips were pretreated with 30% H_2O_2

100X zoom of FCNT doped paper



50X zoomed view of FCNT doped paper



1x zoom of FCNT doped paper exposed to 93ppm aniline w/o H_2O_2

No visible difference, although acetonitrile workup reveals a slight absorbance relative to blank

Reacted Test Strip at 1x at 93ppm Aniline Vapor

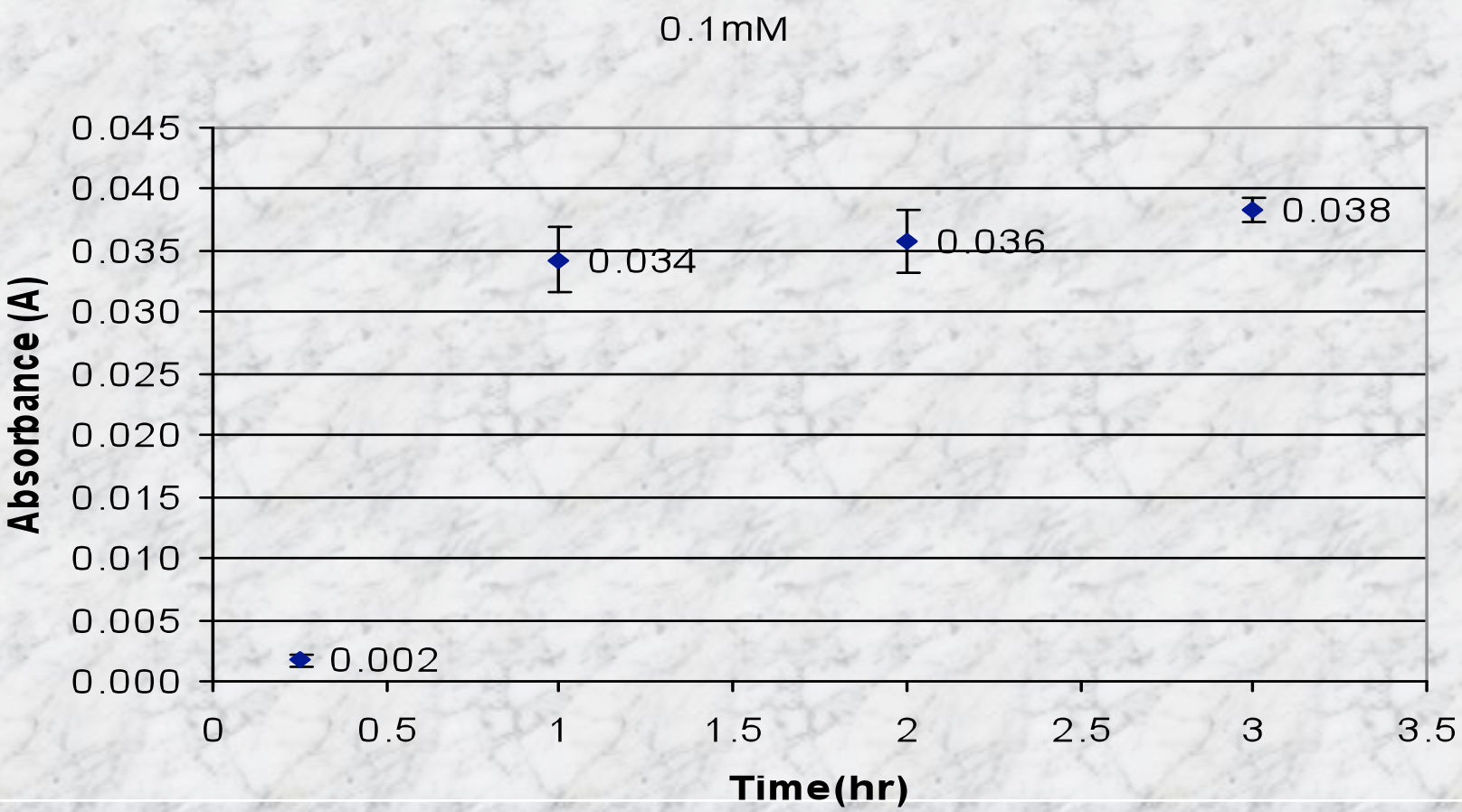
Conclusions

- Centrifugation appears to accelerate the second order process of aniline or p-toluidine oxidation
- It is possible to have a paper sensor based on FCNTs to fight bioterrorism
- The dye industry could also benefit from an economical paper sensor approach

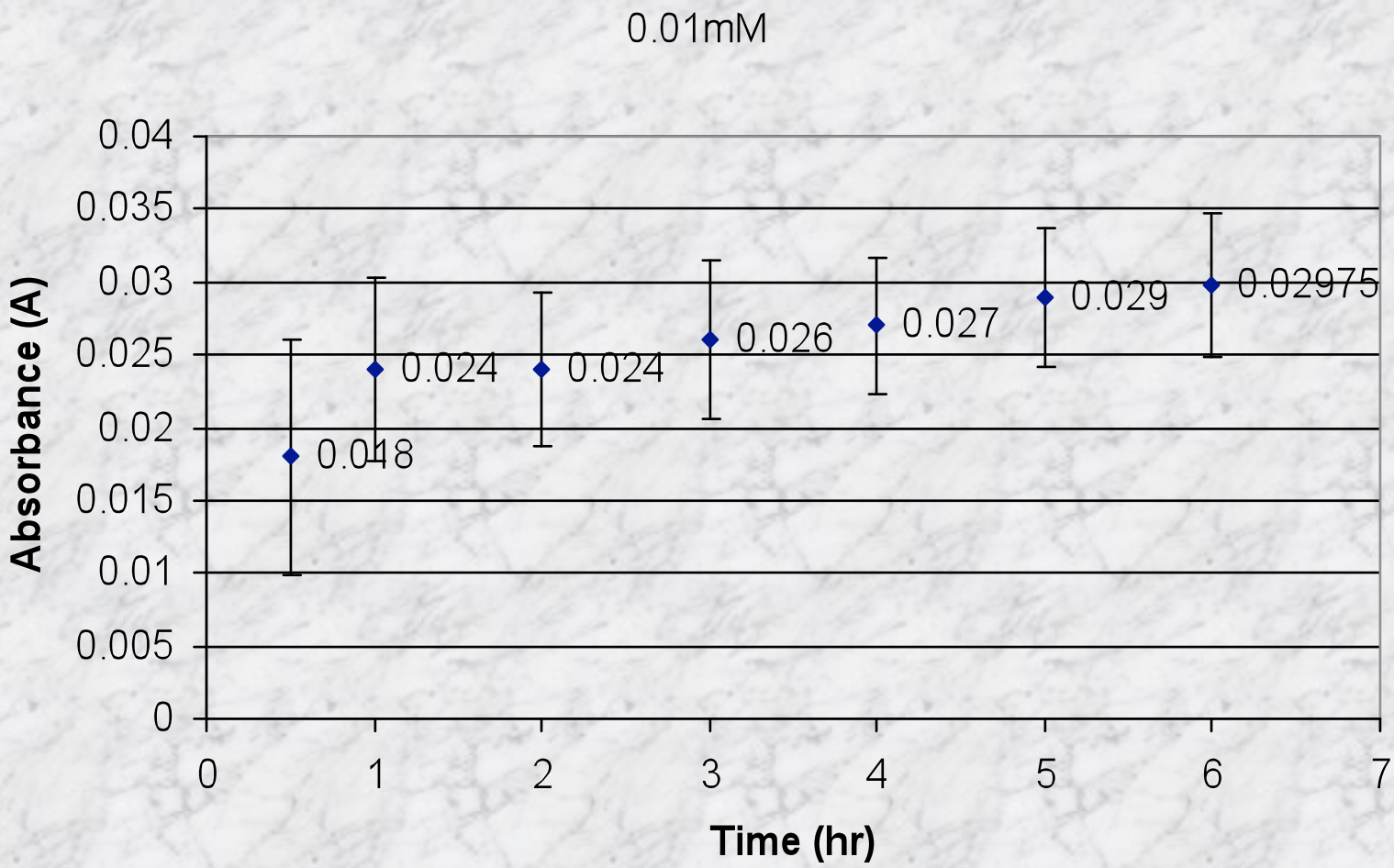
Acknowledgements

- Dr. T.C. Morrill
- Dr. G.A. Takacs
- Brenda Mastrangelo
- Tom Allston

Centrifuge
0.1mM p-Toluidine+0.1mM H2O2



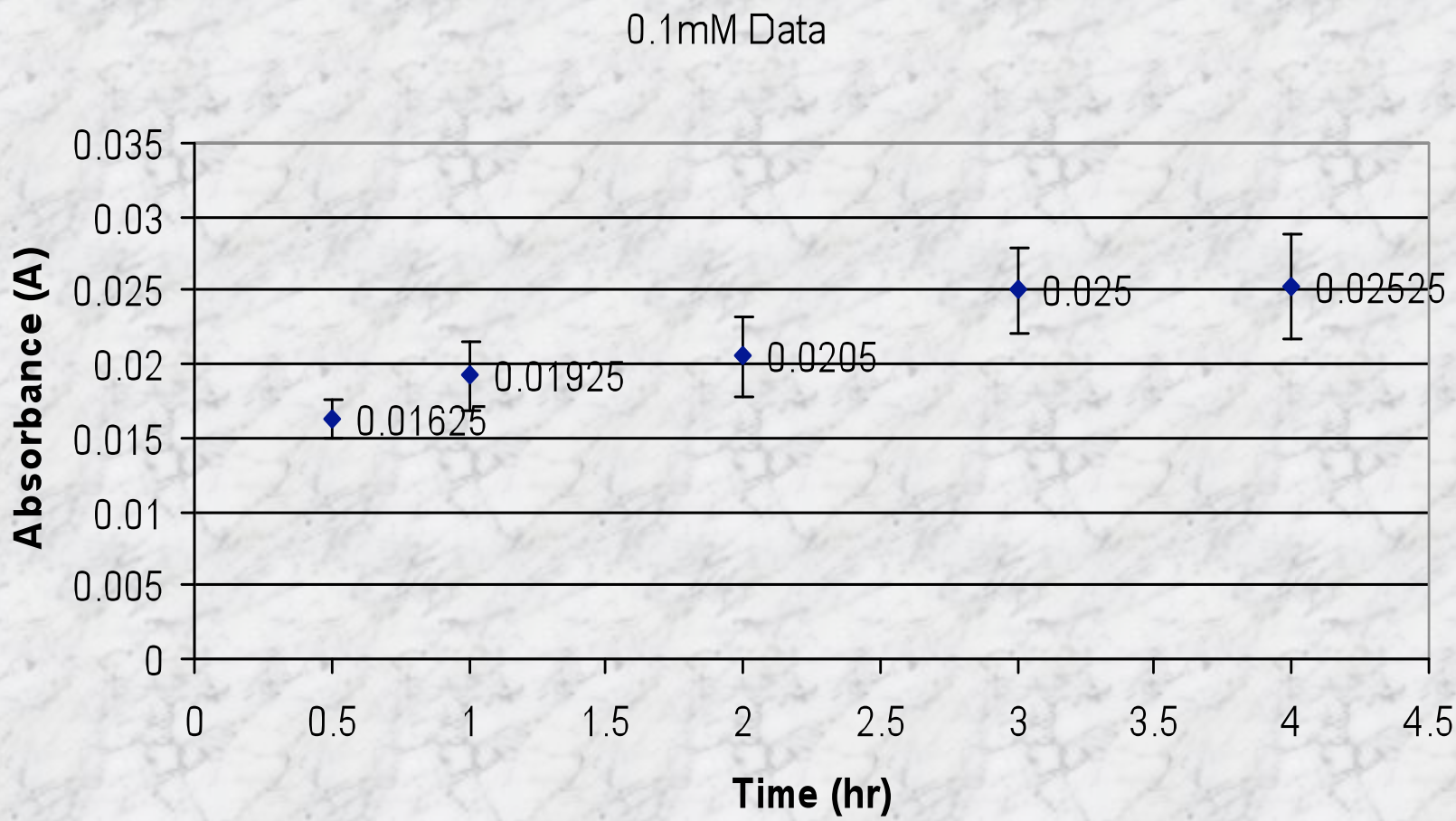
0.01mM Aniline+0.01mM H2O2



Future Work

- Finding a gel electrode sensor that will work
- Increasing the efficiency of the paper strip sensor so less time is necessary for detection
- Application of these methods to other functional groups and molecules

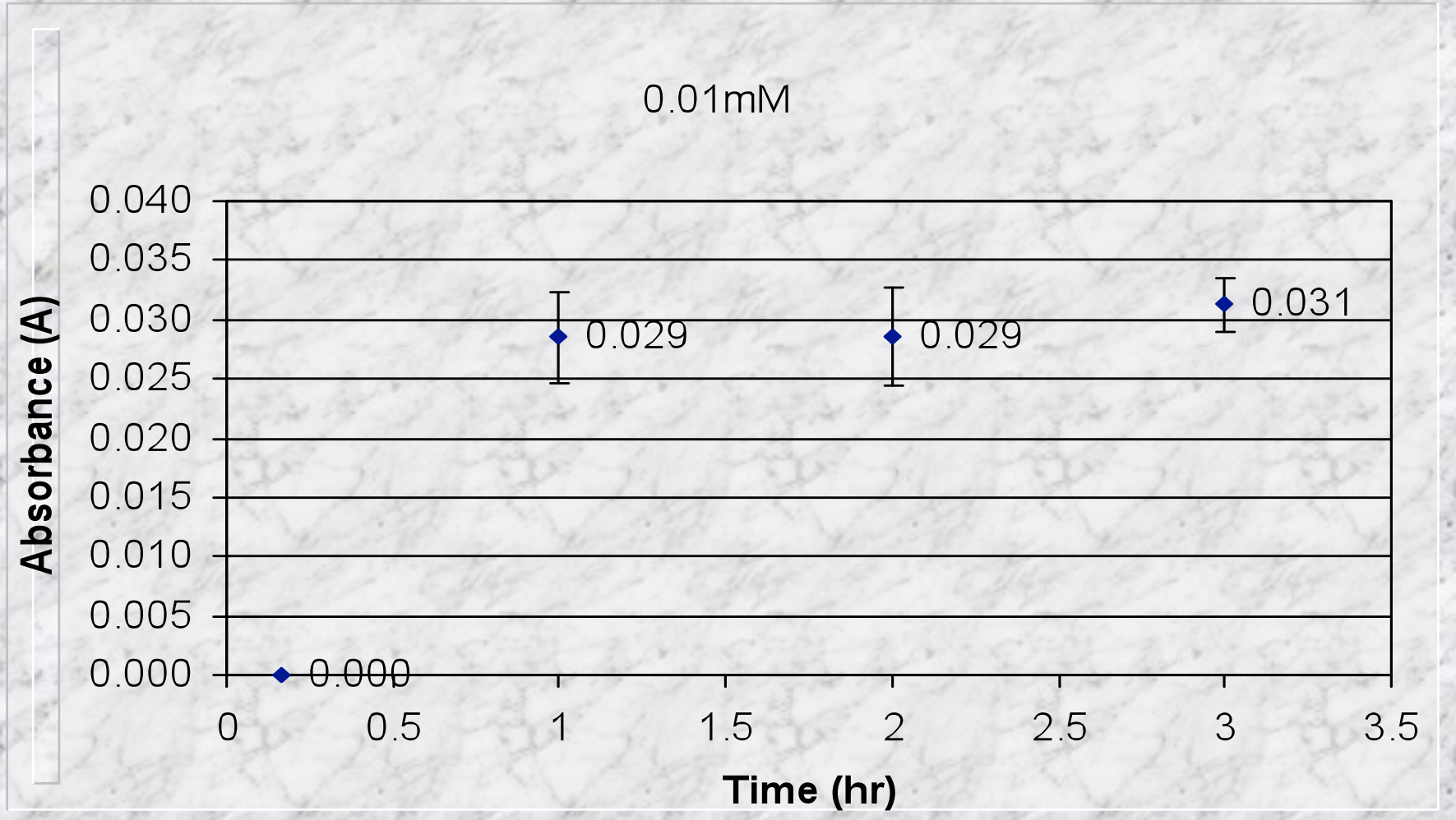
0.1mM Aniline+0.1mM H2O2



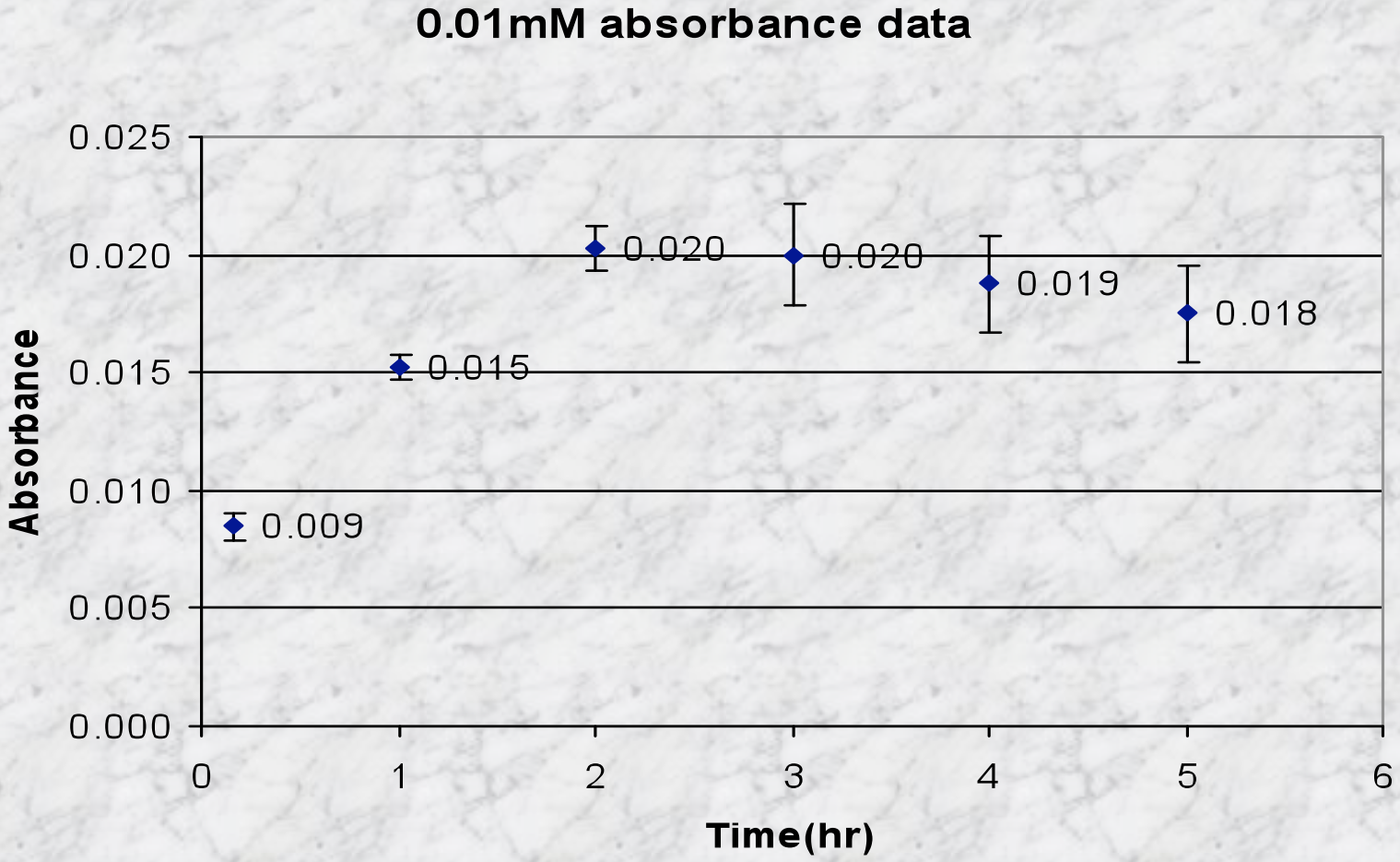
Acceleration of reactions via centrifuge

- Solutions centrifuged at constant 1550 RPM
- Held at room temperature

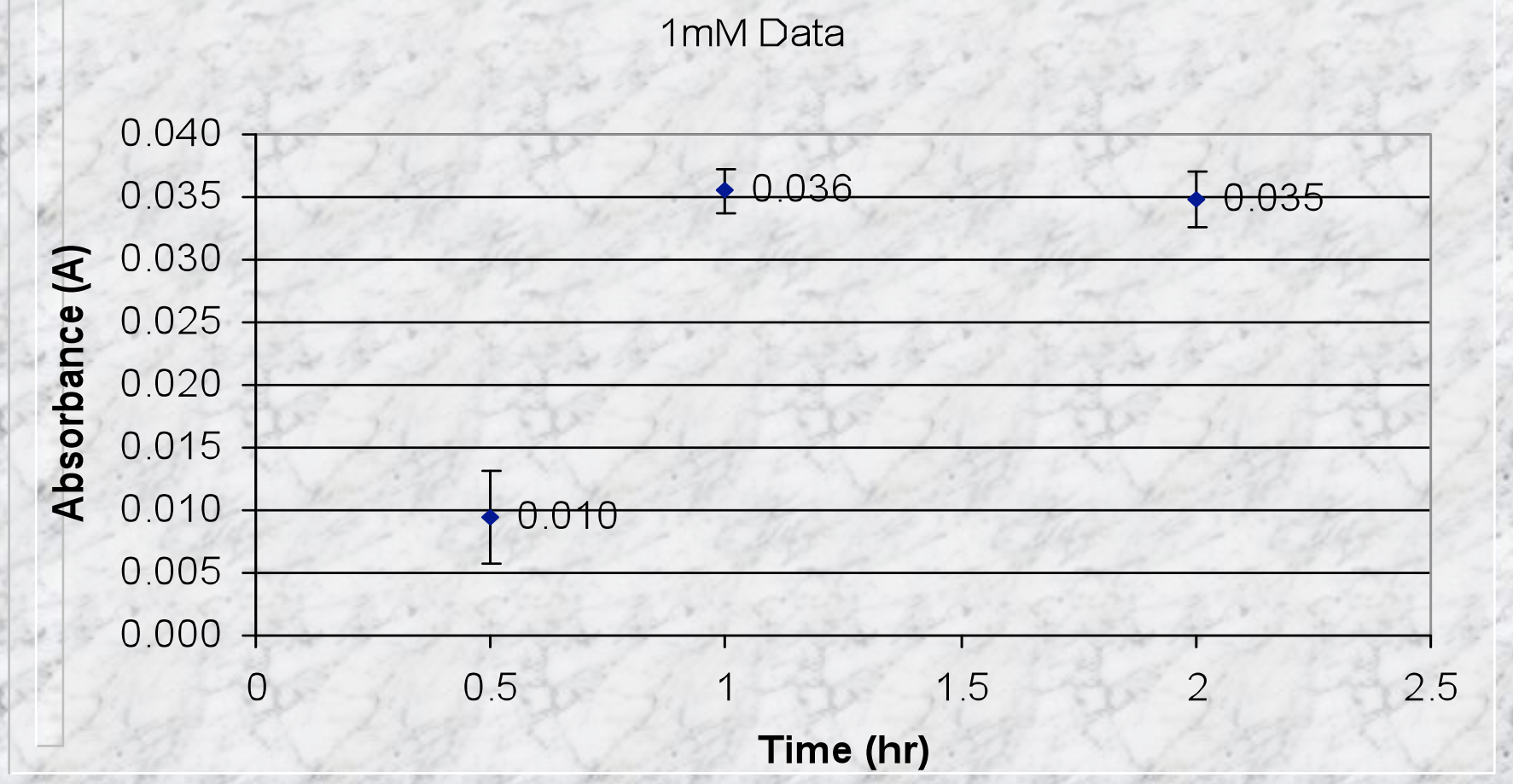
Centrifuge
0.01mM p-Toluidine+0.01mM H2O2



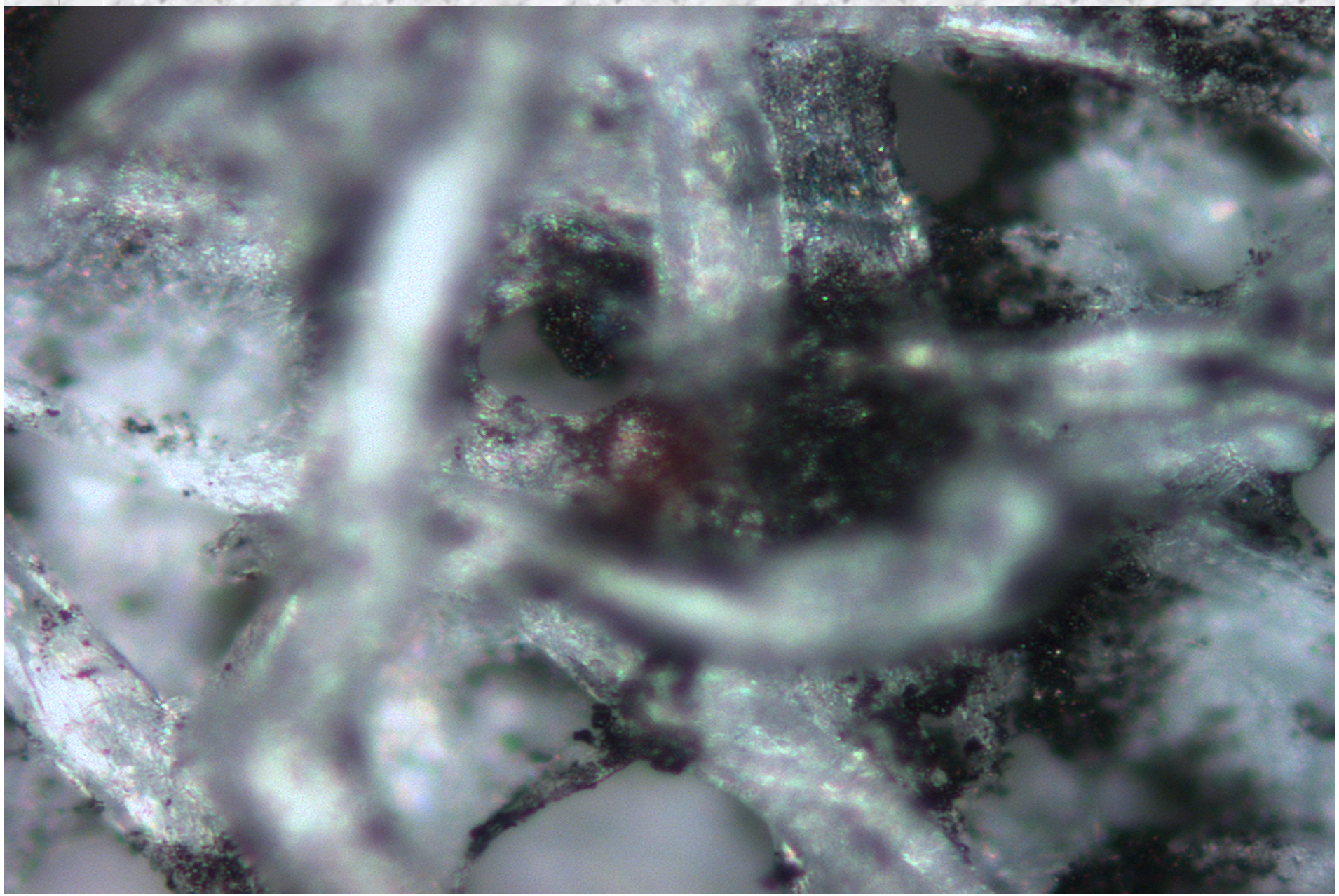
0.01mM p-Toluidine+0.01mM H2O2



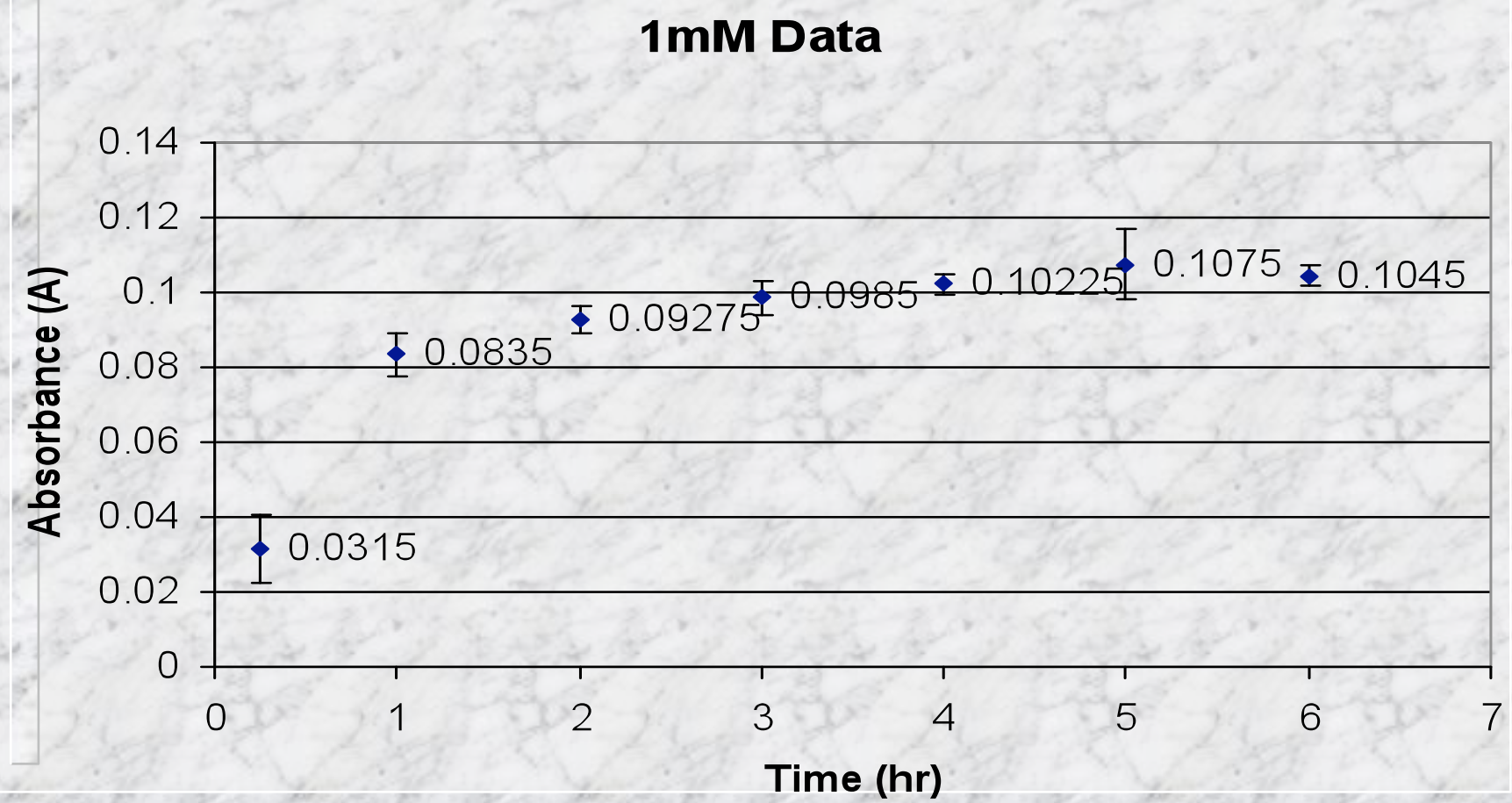
Centrifuge
1mM p-Toluidine+1mM H2O2



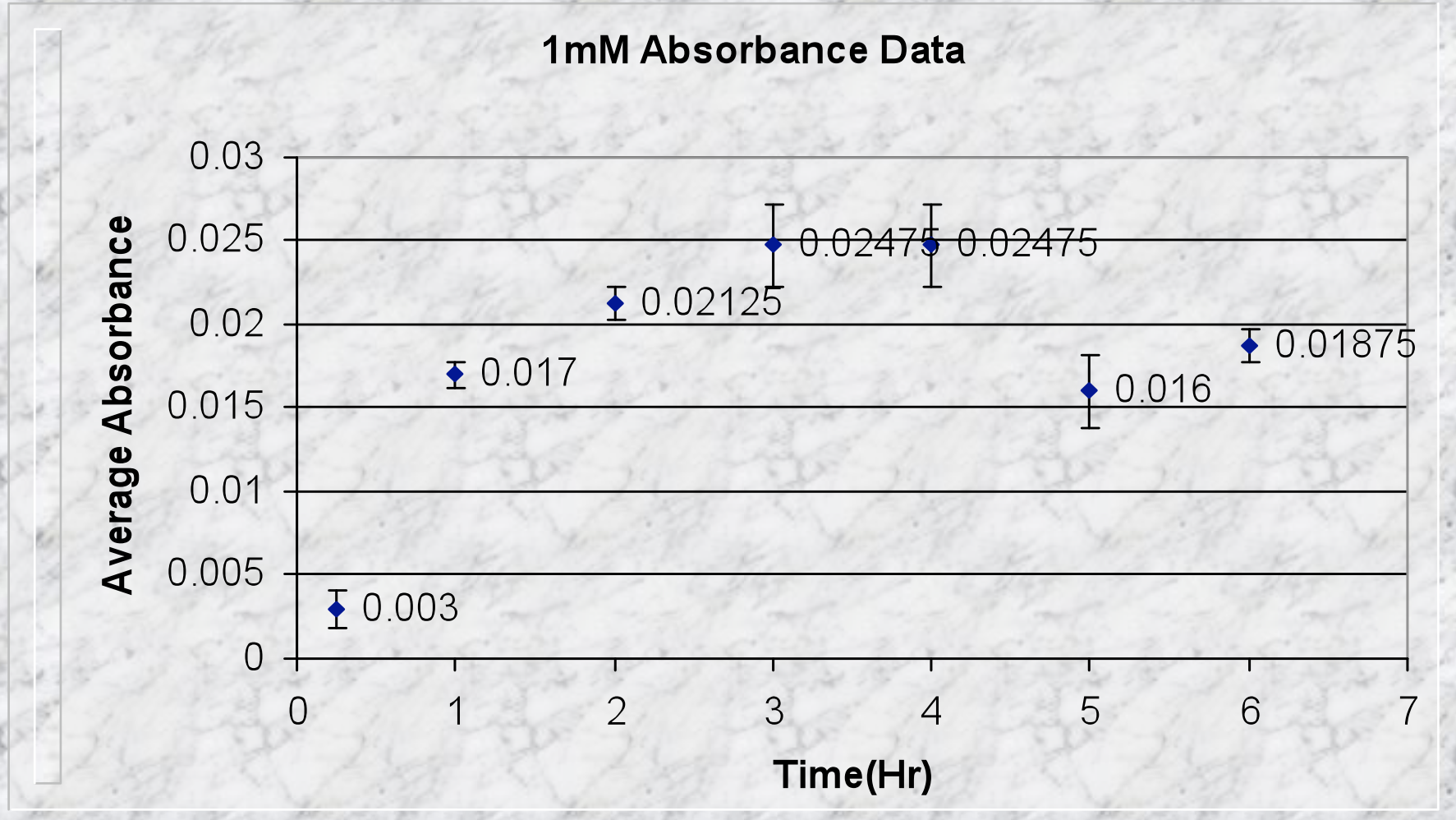
500X zoom of FCNT doped paper



Centrifuged 1mM Aniline+1mM H2O2



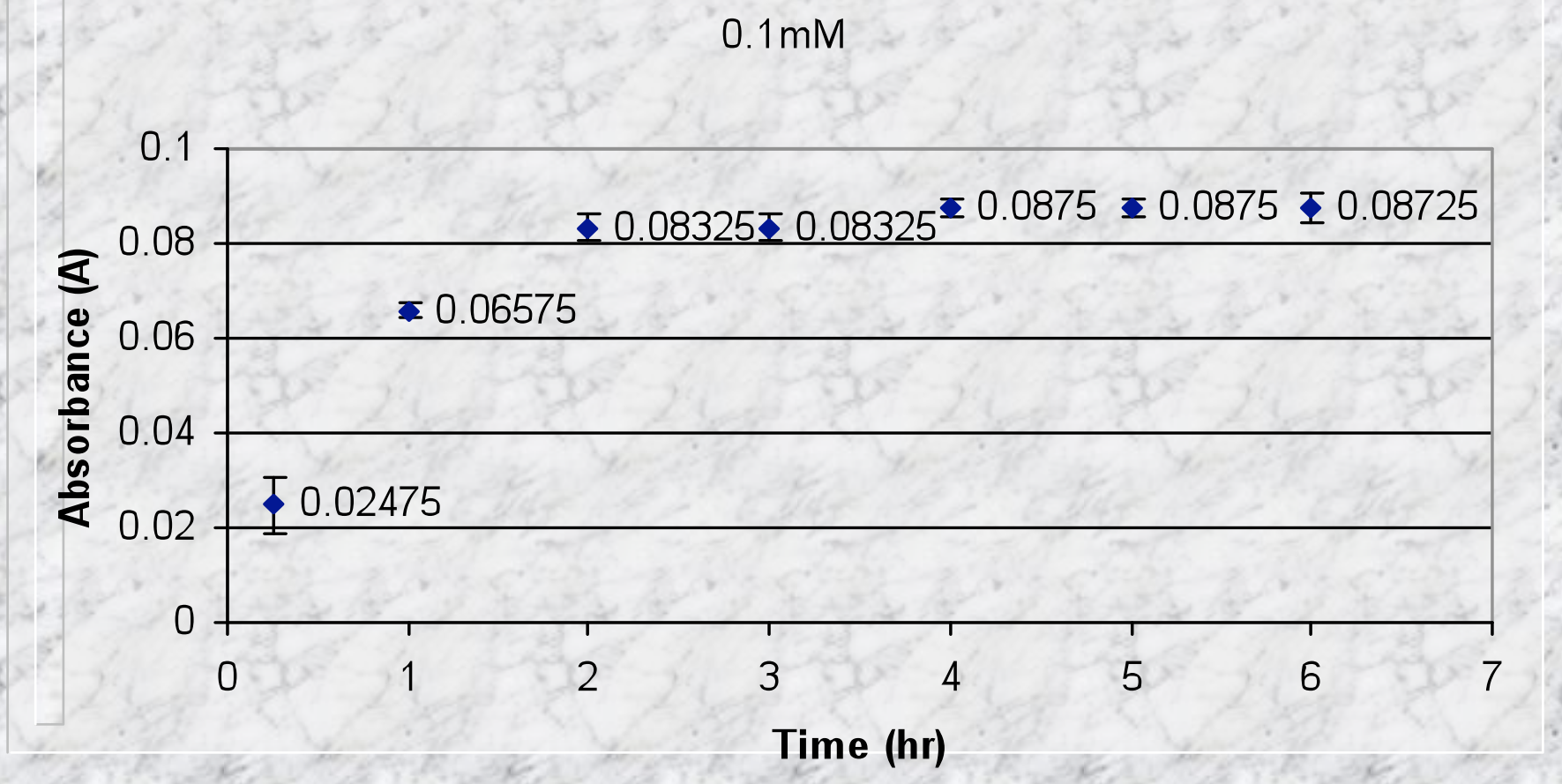
1mM p-Toluidine+1mM H2O2



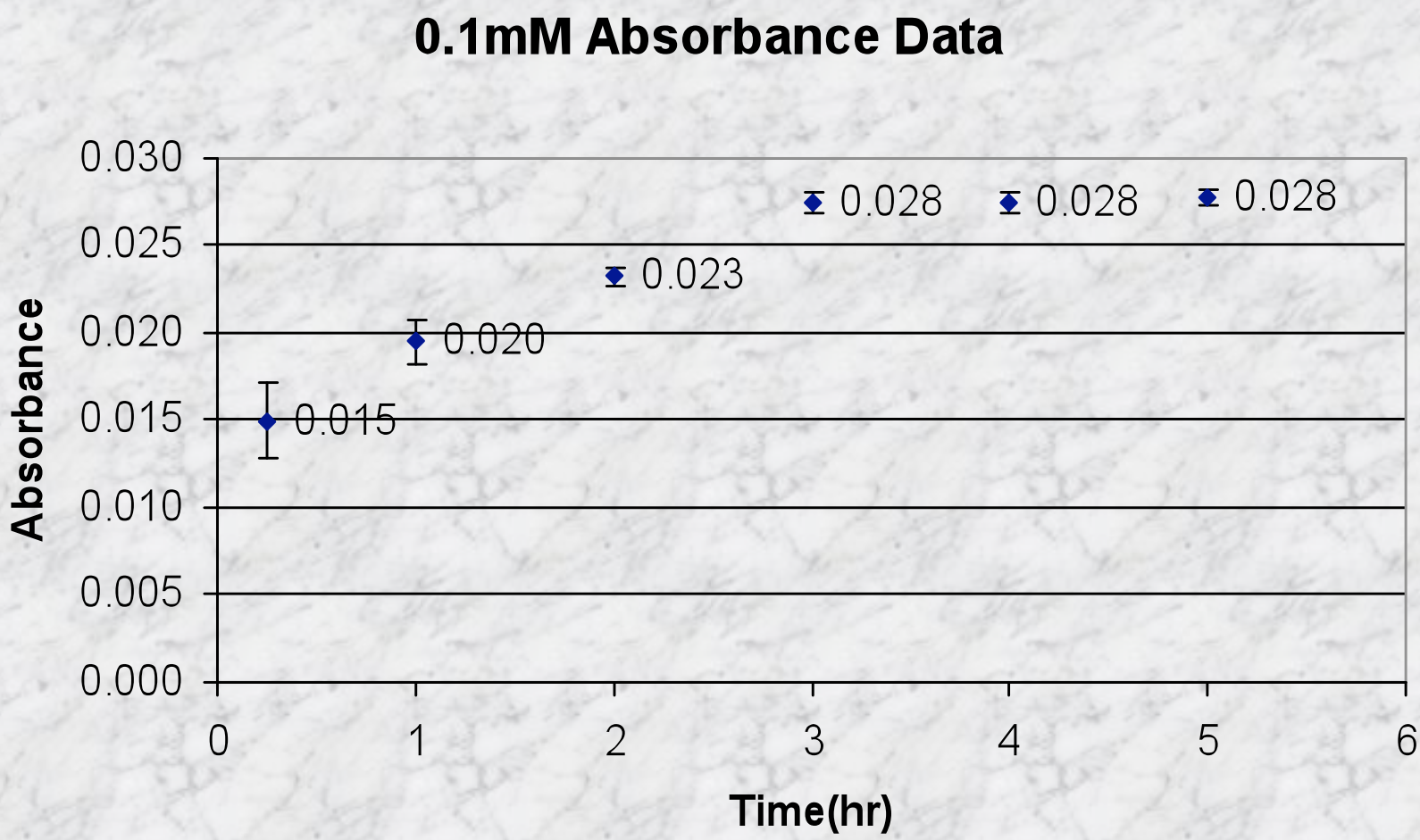
Other Sensor Methods: Electrochemical

- Creating a FCNT doped gel to sit between two electrical leads
  - All preparation methods tested would not solidify as expected
- A FCNT bridge overtop of a “Krazy Glue” binder was placed between two electrical leads to measure resistance changes
  - Results could not be easily replicated
  - Practical issues with electrode preparation

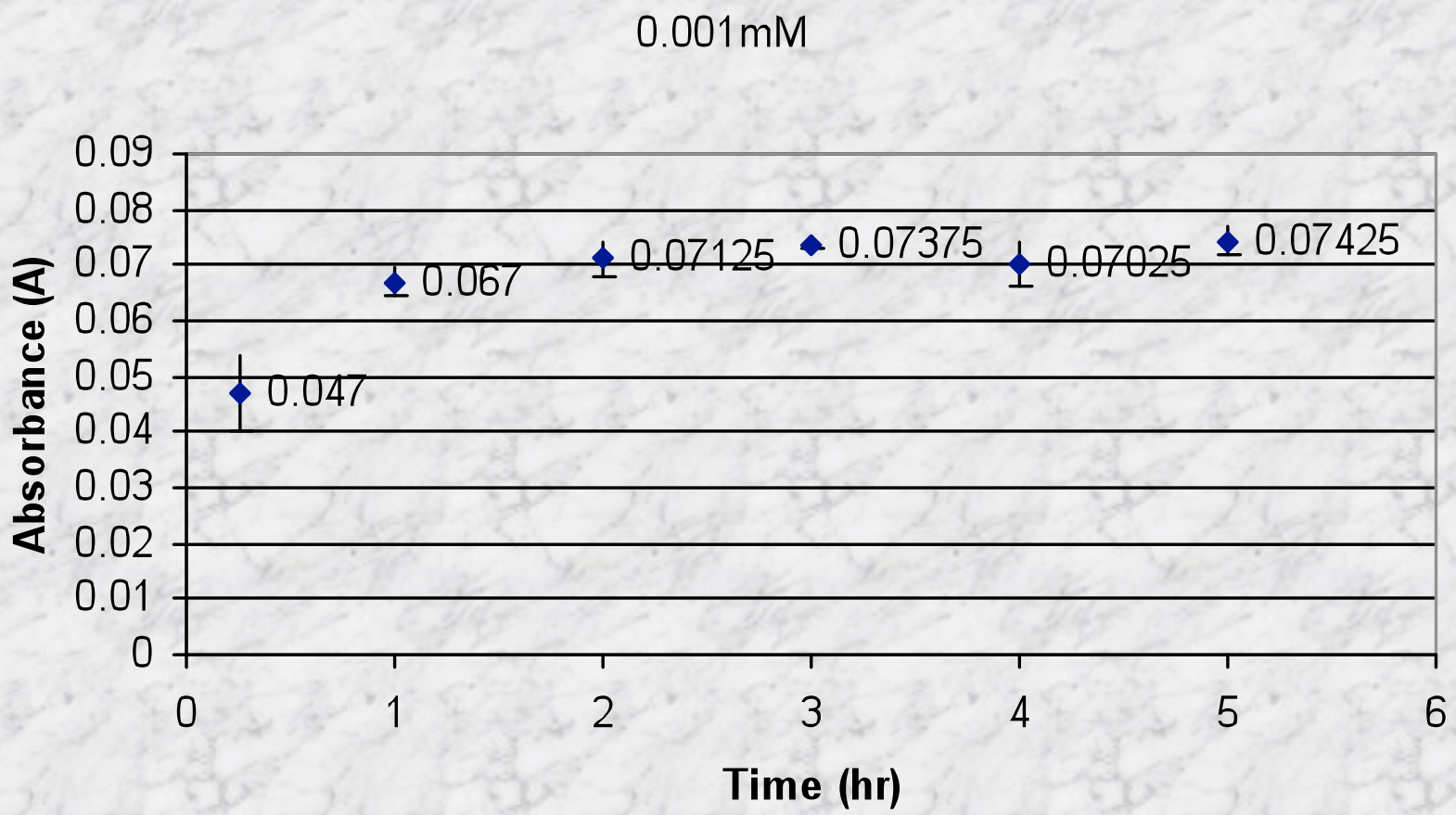
Centrifuged
0.1mM Aniline+0.1mM H2O2



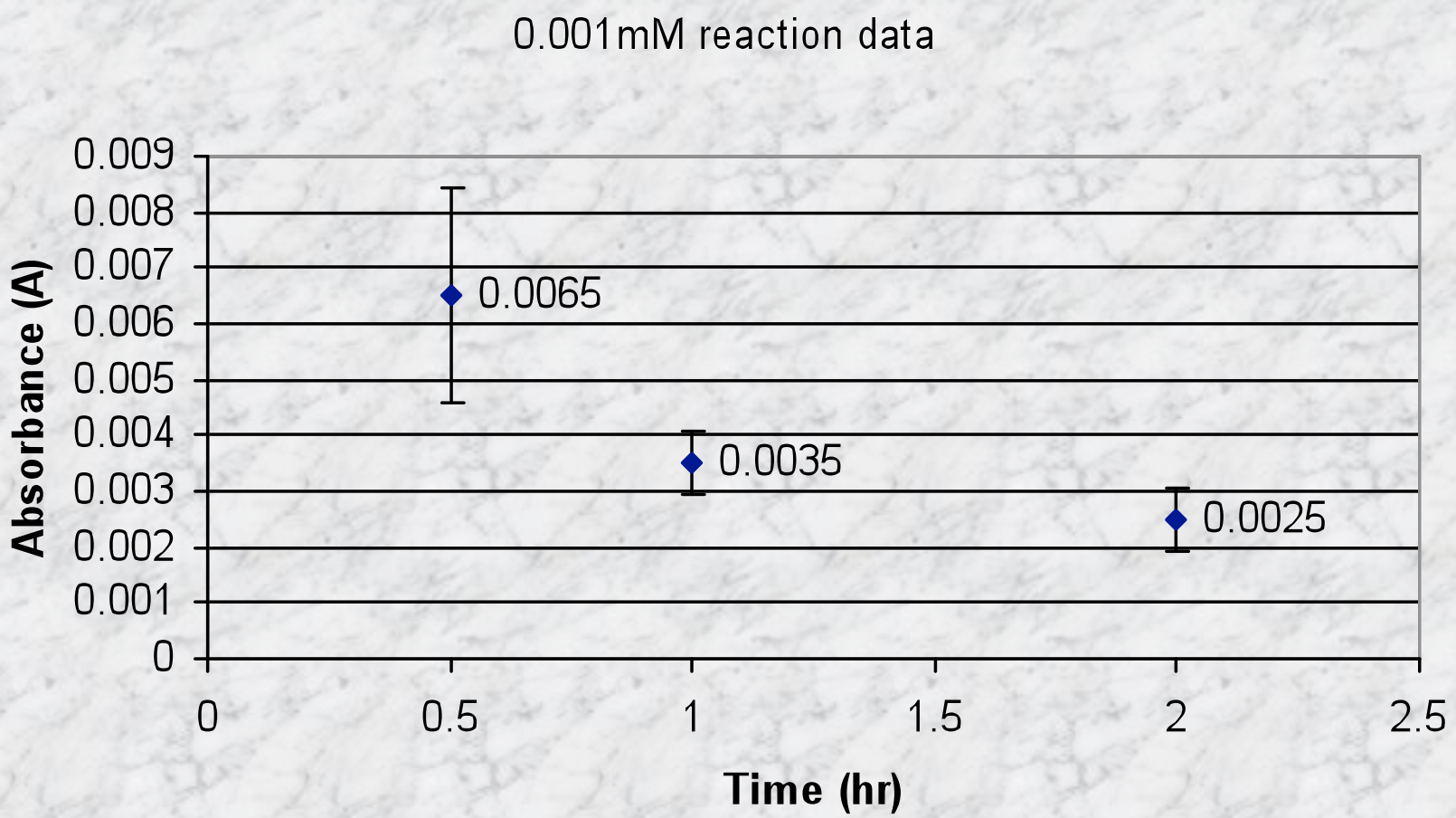
0.1mM p-Toluidine+0.1mM H2O2



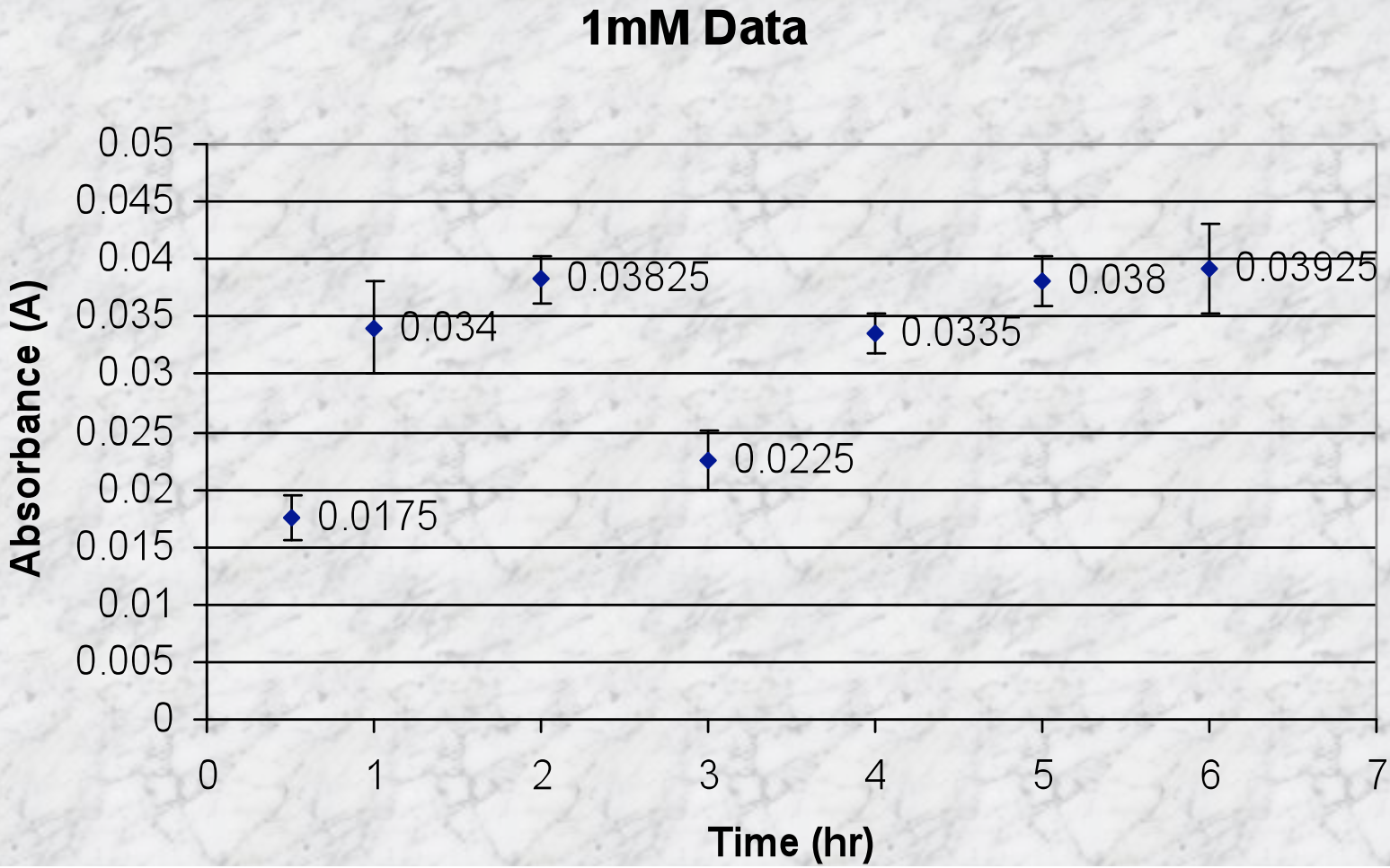
Centrifuge
0.001mM Aniline+0.001H2O2



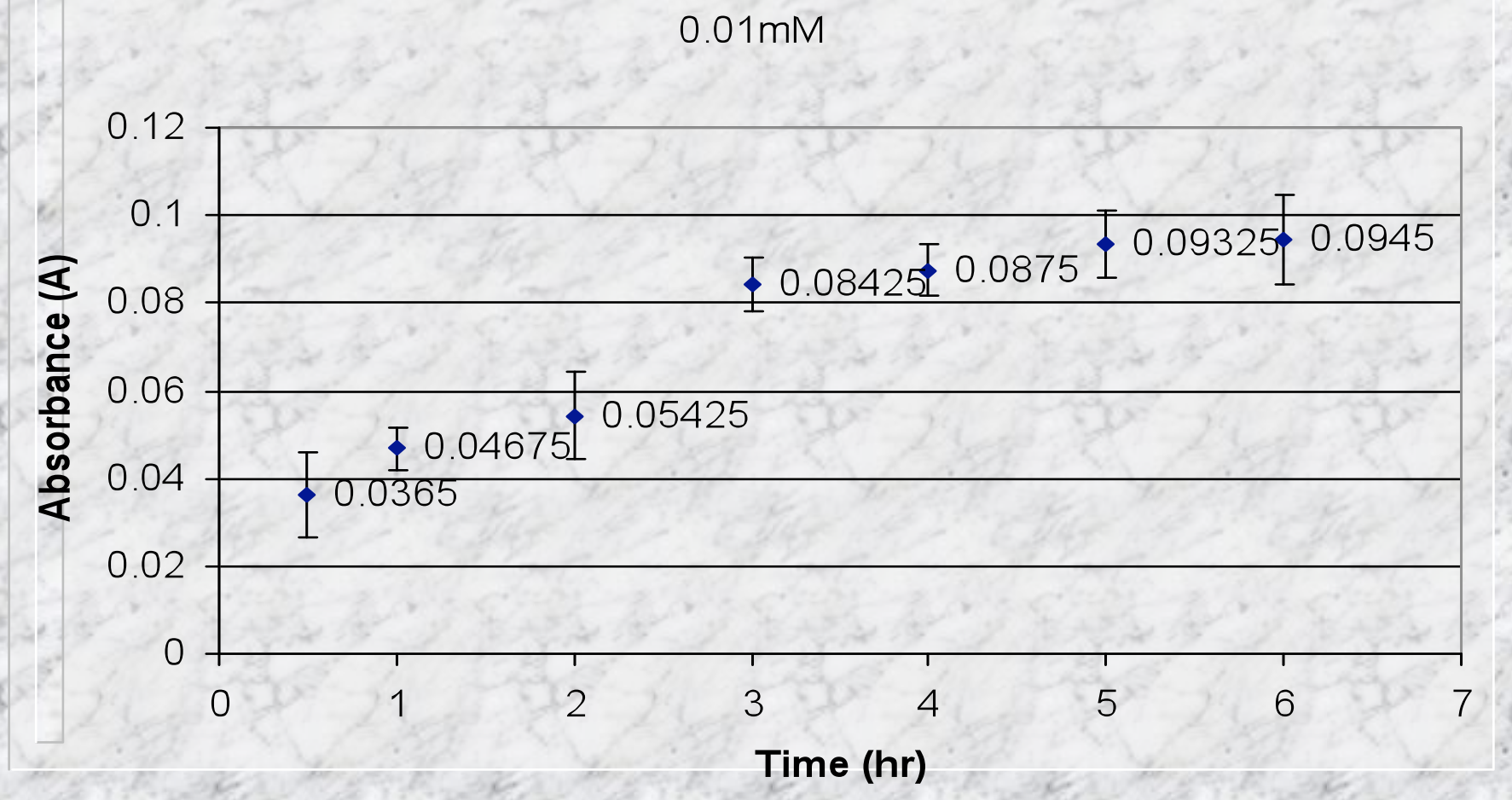
0.001mM Aniline+0.001mM H2O2



1mM Aniline + 1mM H2O2



Centrifuged 0.01mM Aniline+0.01mM H2O2



1X zoom of FCNT doped paper